102. Global Drop Size Distributions and Implications for GPM Rain Mapping

ATMOSPHERIC SCIENCE
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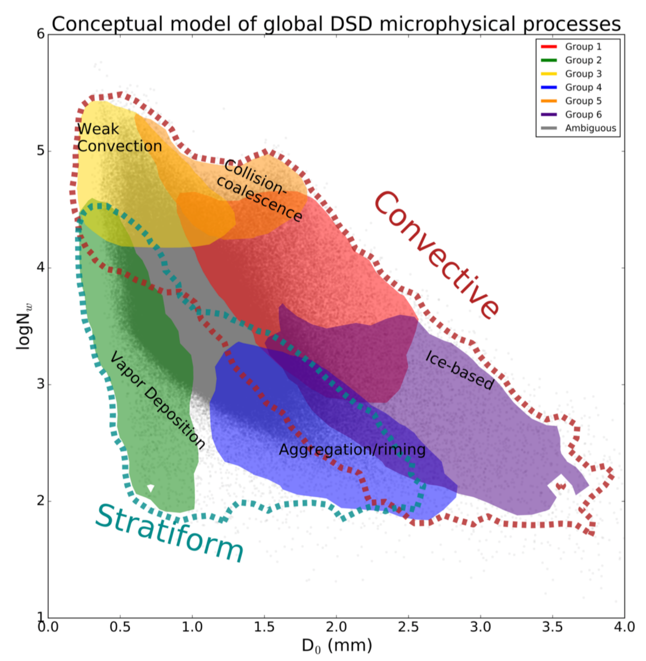
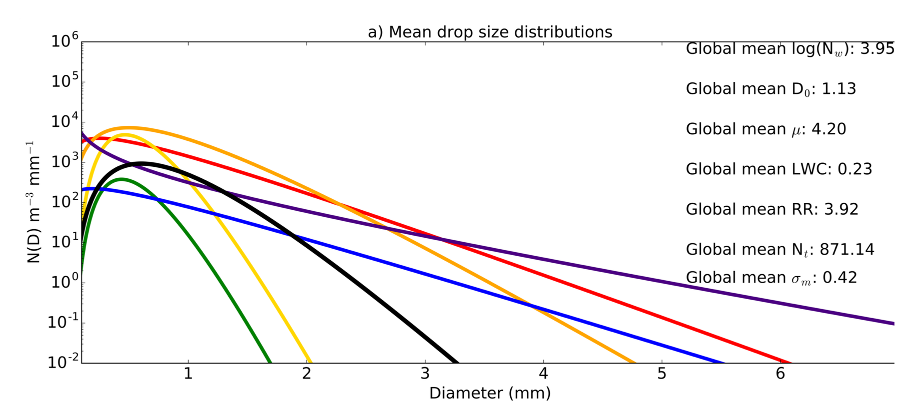
Introduction

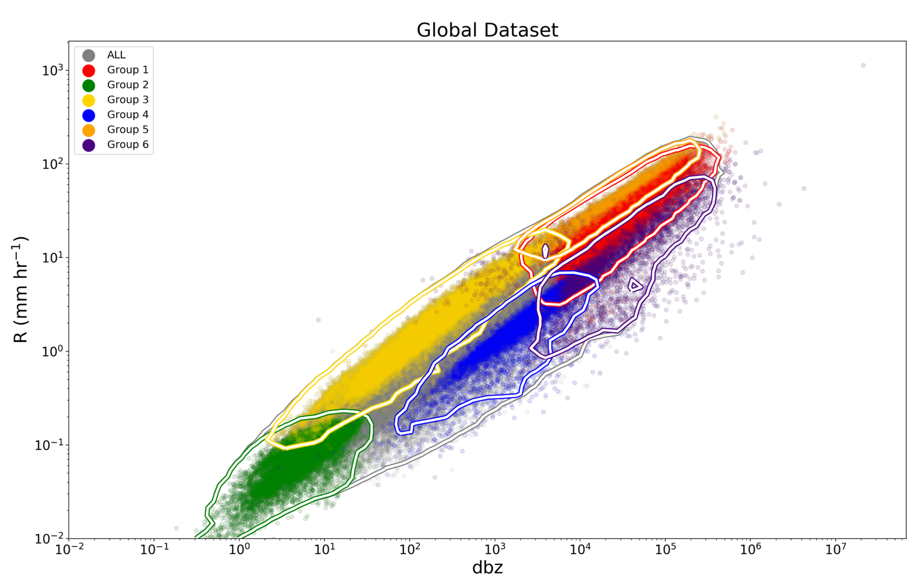
Understanding the variability of drop size distributions (DSDs) is vital for estimation of precipitation from remote sensing instruments. For example, the relationship between radar reflectivity (Z) and rain rate (R) is fundamentally tied to the DSD. Therefore, a better understanding of DSD variability could serve to constrain retrieved rainfall from sensors such as GPM's dual-frequency precipitation radar (DPR). Dolan et al. (2018) applied principal component analysis (PCA) to a set of global disdrometer observations containing over 300000 raining minutes and found six different groups of DSDs with similar characteristics. Through coincident radar analysis, these groups were found to be generally associated with different types of precipitation, such as convective and stratiform organization, and ice-based and warm cloud processes. Herein, we take the analysis a step further to understand how the six groups are distributed, how they relate to retrieved precipitation characteristics, and how the DSDs might be linked to large scale environment.



DSD Group Relationship to Measurements

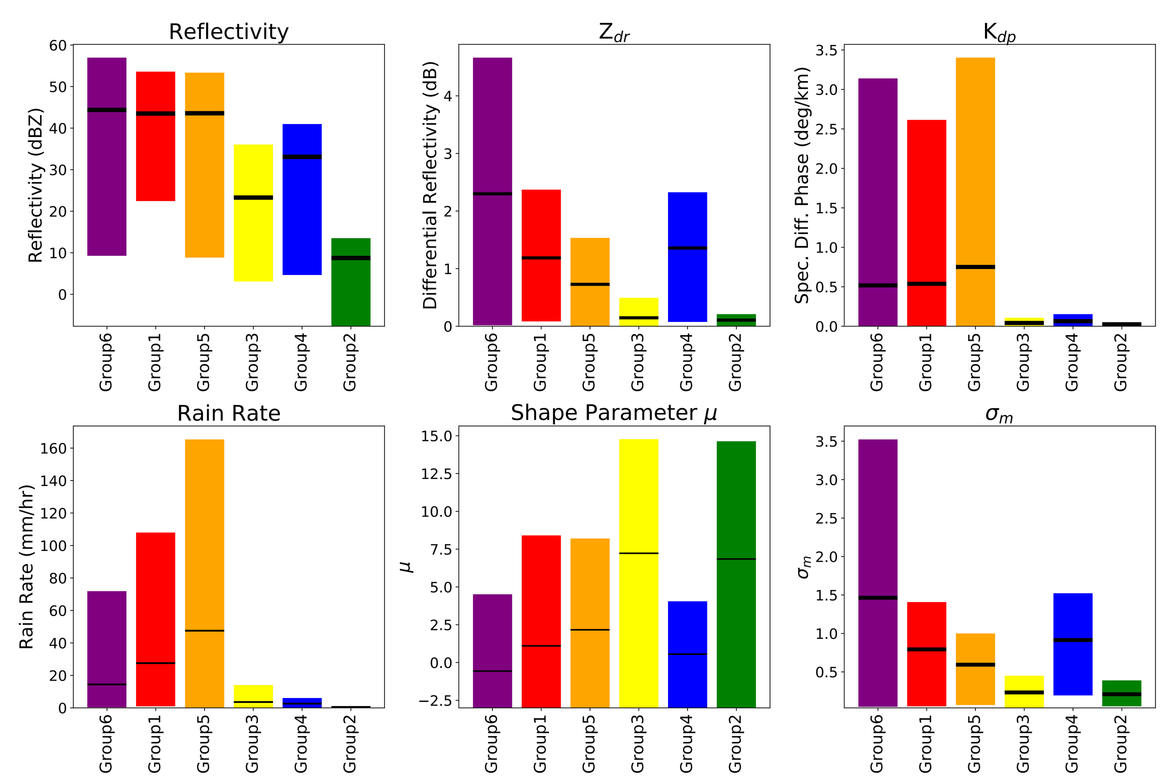


Drop size distributions associated with each Group



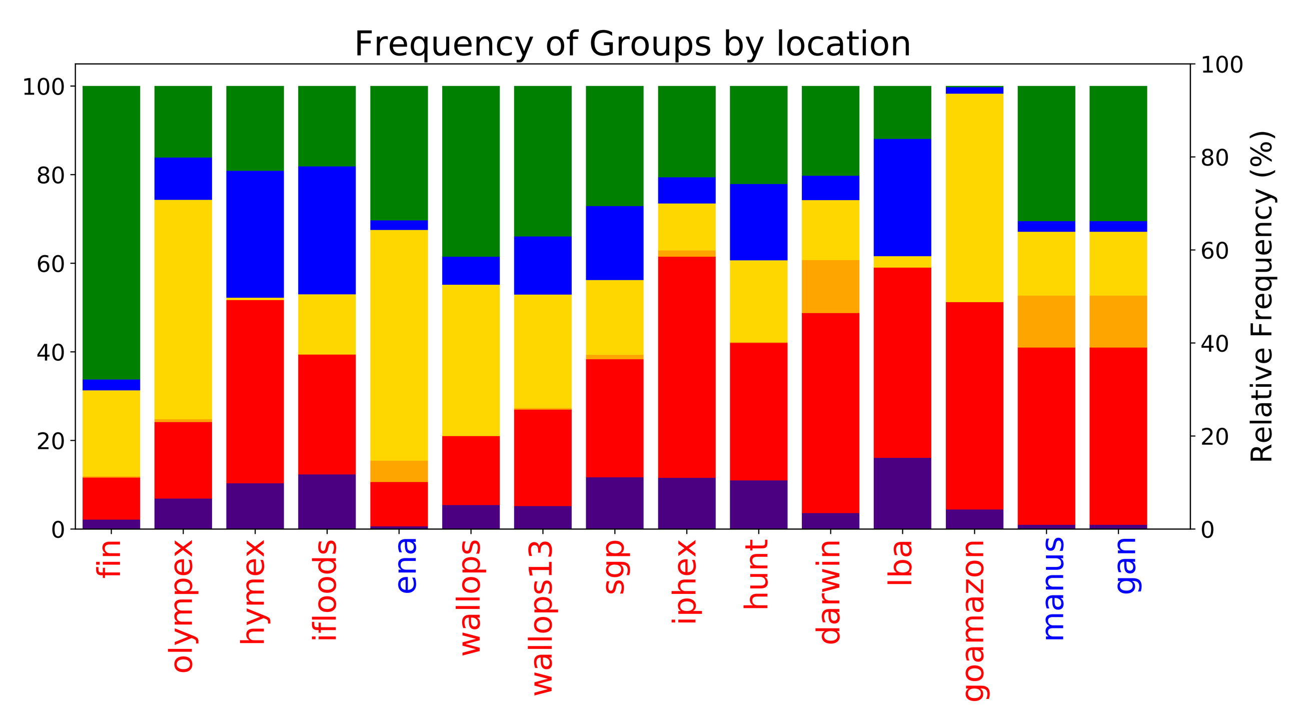
Relationship between Z and R for each Group

- Distinct DSD with each Group
- Although Group 1, 5, and 6 have similar ranges of Z, Group 3 has the highest R
  - Kdp is large for all groups, but Zdr is smallest for Group 5
  - σ_m is largest for Group 6 and smallest for Group 5
- Group 2 and Group 3 have similar characteristics, but Group 2 has smaller Z
- Group 3 and Group 4 have similar ranges of Z, but Group 4 has larger Zdr and σ_m



Range of parameters associated with each Group

Spatial Frequency Distributions



Increasing absolute latitude

Trends:

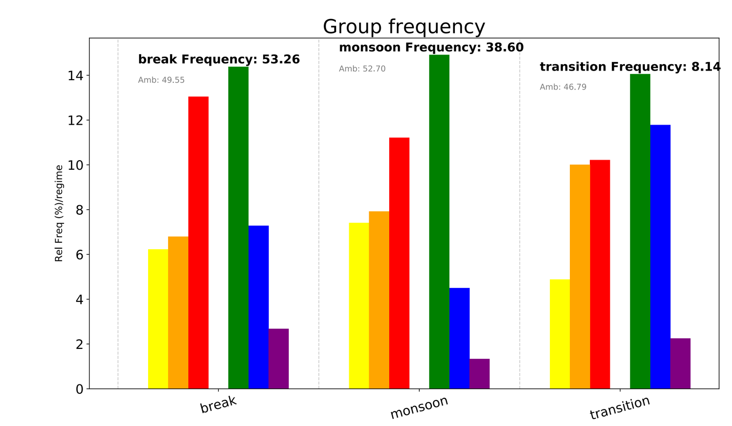
- More contribution from Group 3 with increasing latitude
- More contribution from Group 1 with decreasing latitude
- Island / Oceanic sites have notable contributions from Group 5, but little Group 4 and almost no Group 6
- Group 6 has largest contributions in continental locations

Environmental Link to DSD

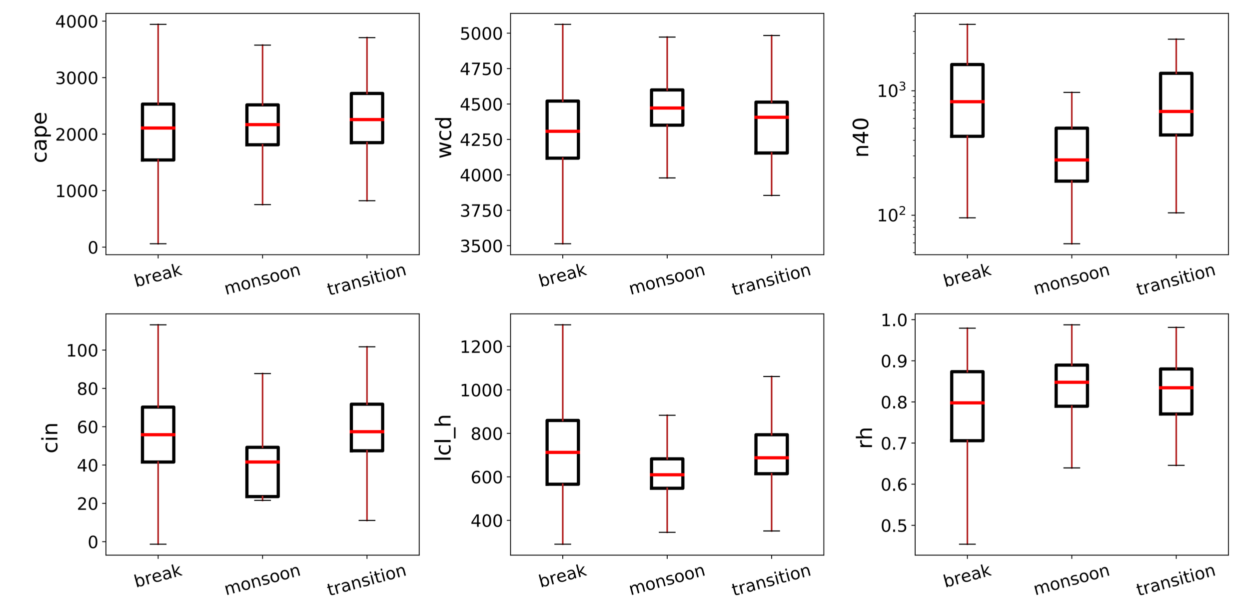
To explore possible environmental influences on DSDs, we attributed MERRA2 reanalysis data to locations with long-term (>=1 year) disdrometer observations. Additionally, to look at potential aerosol impacts, we used the GEOS-CHEM global model and the TOMAS aerosol microphysics module. From these attributes, we analyzed the distributions associated with different environments and as a function of the Groups identified by PCA.

Darwin: A Case Study

The Monsoon and Break regimes provide contrasting environments to study DSD variability (as has been shown by many previous studies)

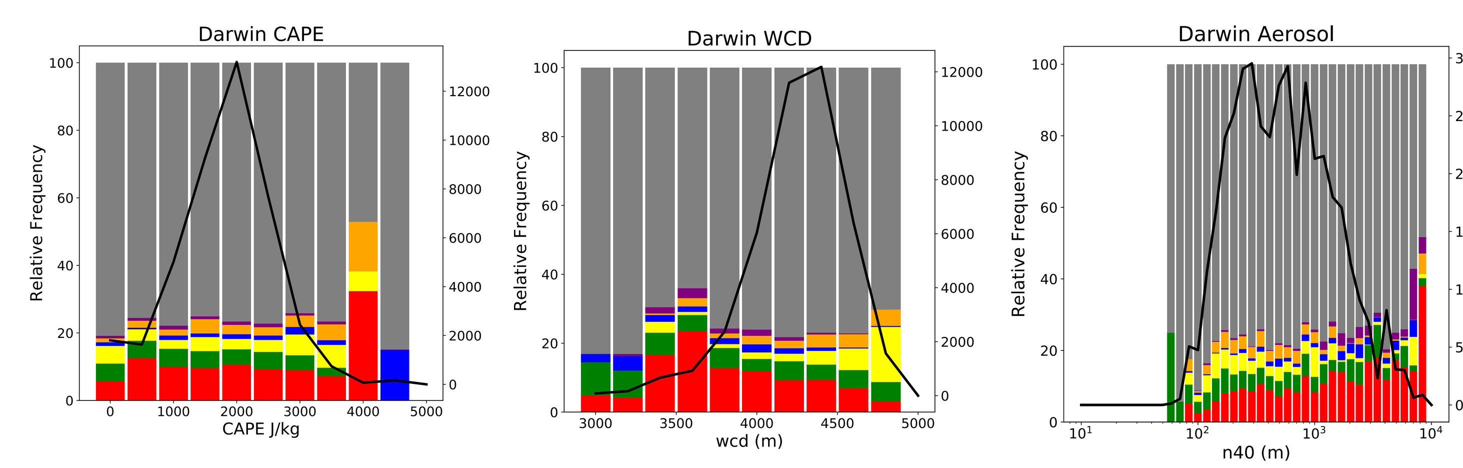


- Break periods have larger component of Group 6, Monsoon has higher Group 5



Environmental Characteristics of monsoon (u850>2 ms^{-1}) and break (u850 <-2 ms^{-1}) periods

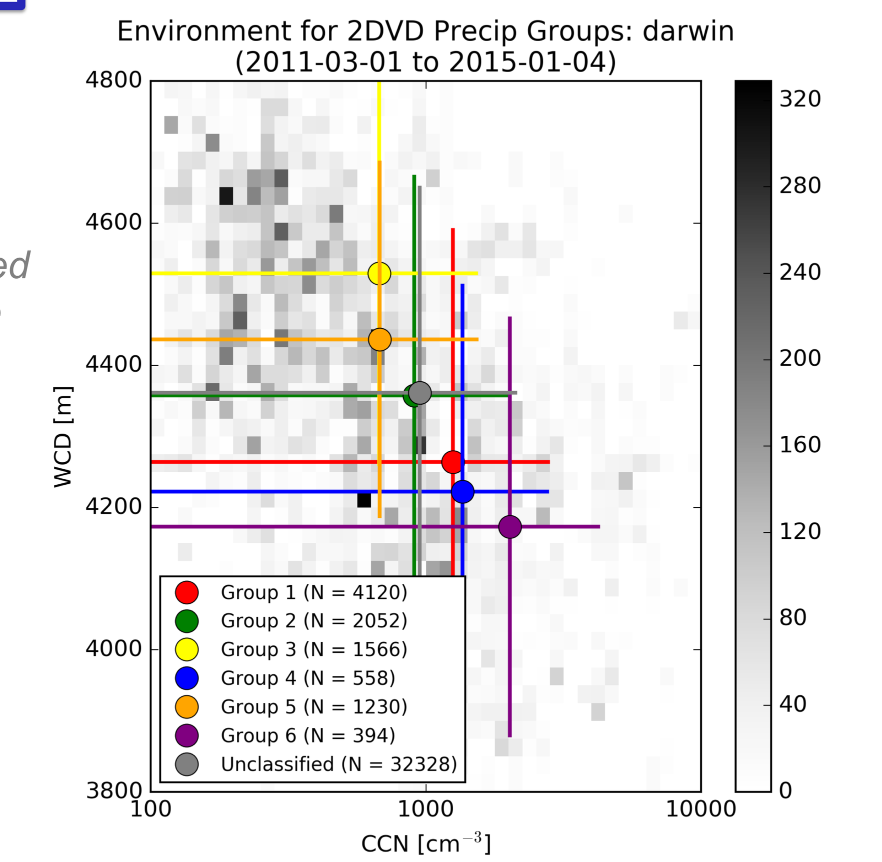
- Break: larger range of warm cloud depth (WCD), N40 aerosols, convective inhibition (CIN), and lifted condensation levels (LCLs)
- Little variability associated with CAPE in Darwin



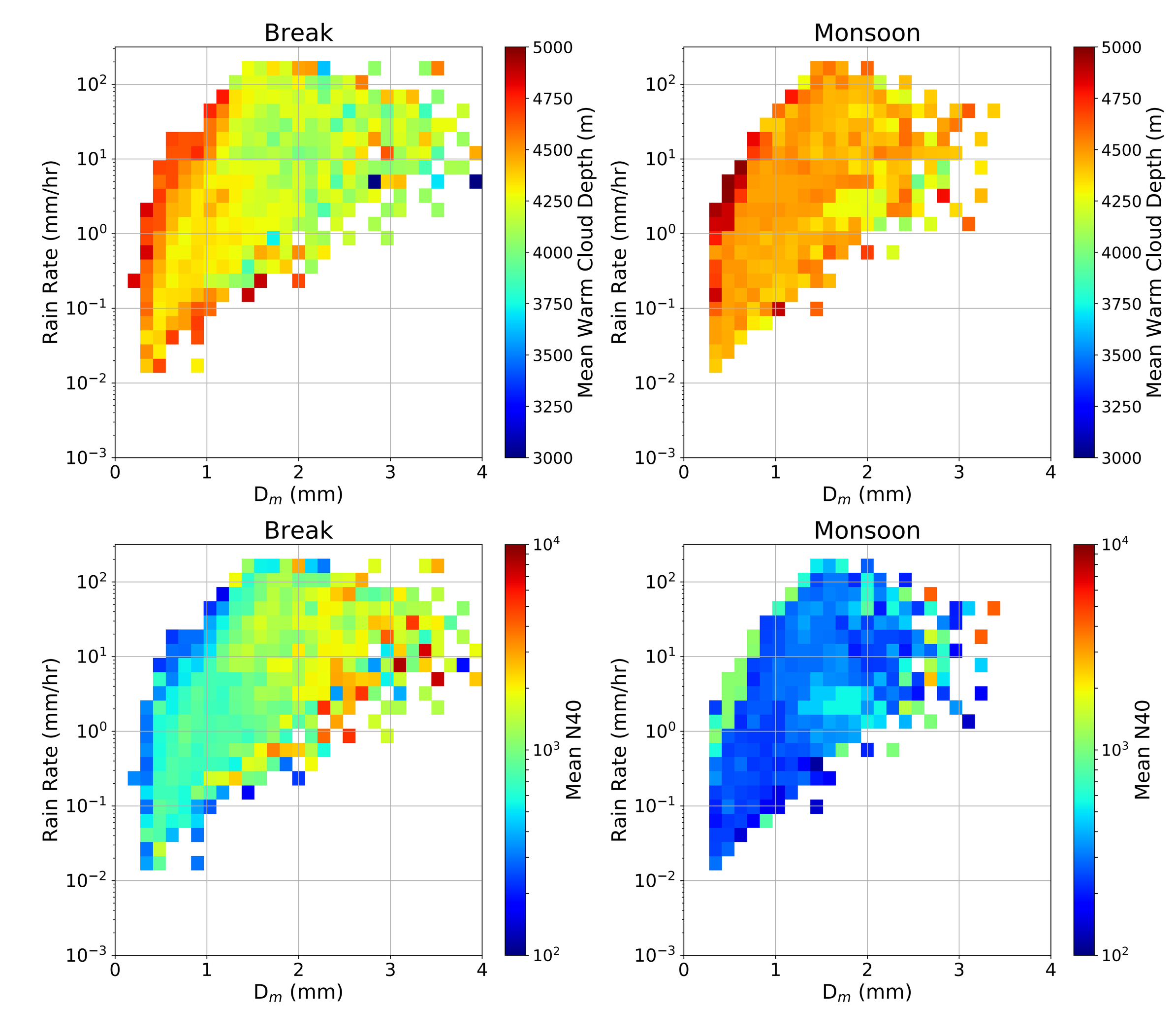
Relative Frequency of Groups associated with environmental parameter bins. Black line indicates the number of points in each bin

- Increasing frequency of Group 3 (shallow, weak) and Group 5 (robust warm rain) convection with increasing WCD and decreased N40
- Inversely, higher frequency of Group 6 (ice processes) with increasing N40 and decreasing WCD

Grayscale shading indicates the 2D frequency PDF; colored dots and bars indicate the mean (dot) and standard deviations (bars) of each Group



- Group 6 (ice processes) : High N40 coupled with shallow WCD
- Group 5 (warm rain): Deep WCD and low N40 concentrations



2D frequency of R-Dm colored by mean WCD (top) and N40 concentration (bottom)

- Deeper WCD and lower N40 result in higher R and smaller D_m
- Shallower WCD and increased N40 lower the R for a given D_m

Acknowledgements

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Summary

Building on the PCA methodology and disdrometer dataset outlined in Dolan et al. (2018), spatial and environmental variability is explored as a function of six DSD groups. We find the DSD groups are associated with different distributions of reflectivity and other remote sensing parameters such as Kdp and Zdr, which has implications for precipitation retrievals. We also find that the relative frequency of different groups is a function of latitude and continental or oceanic locations. Lastly, we have attributed environmental parameters to the DSD data. A case study from Darwin finds that Group 6 (ice-based processed) occurs more frequently with shallow warm cloud depths and high CCN concentrations, conditions which are generally associated with the break periods. Conversely, robust warm rain (Group 5) is associated with deep warm cloud depth and low aerosol concentrations, which are common during monsoon periods. We plan to perform similar analysis to other long-term datasets in different locations, such as the DOE Southern Great Plains site in Oklahoma, and potentially extend the methodology to snow PSD observations. We hope the findings can constrain retrievals of precipitation such as those from GPM.